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- (43) Publication Date: 11.09.86
- (44) Publication Date of Accepted Application: 26.11.87
- (71) Applicant HOECHST A.G.;
- (72) Inventor NAME NOT GIVEN
- (74) Attorney or Agent EDWD. WATERS & SONS
- (54) Title PHARMACEUTICAL PRODUCTS WITH PROTRACTED RELEASE WHICH CONTAIN REGULATORY PEPTIDES
- (57) IMPLANT INCLUDES TABLETS, FLAKES AND INJECTIONS. Claim
- An implant containing a regulatory peptide or one 1. of its analogs as the active compound and naturally occurring poly-D(-)-3-hydroxybutyric acid of the formula

$$_{\text{CH}_{3}}^{\text{HO-CH-CH}_{2}-\text{CO-(O-CH-CH}_{2}-\text{CO-)}_{n^{\text{O-CH-CH}_{2}-\text{COOH}}}^{\text{CH}_{3}}$$

in which n represents a number / between 500 /and 25,000, as the biologically degradable carrier.

(CONVENTION. By one or more persons and/or a Company.)

COMMONWEALTH OF AUSTRALIA

Patents Act . 952-1969

# CONVENTION APPLICATION FOR A PATENT

il) Hêrê înserê (in	— MOECHST AKTIENGESELLSCHAFT,		
full) Name or Names of Applicant or	We		
Applicants, followed by	of 45 Bruningstrasse,		
Address (cs).	D-6230 Frankfurt am Main 80,		
	Federal REpublic of Germany.		
•••			
• (2) Here insert Title • of Invention.	hereby apply for the grant of a Patent for an invention entitled: (2)		
	PHARMACEUTICAL PRODUCTS WITH PROTRACTED RELEASE WHICH		
•	CONTAIN REGULATORY PEPTIDES, AND PROCESSES FOR THEIR		
••••			
•	PREPARATION.		
(3) Here insert number(s)	which is described in the accompanying complete specification. This application is a		
of basic application(s)	Convention application and is based on the application numbered (3)		
••••	P 33 27 856.3 and P 33 36 197.5		
(4) Here insert			
Name of basic Country or Countries, and hasic date of	for a patent or similar protection made in Federal Republic of		
	Germany on 2nd August, 1983 and 5th October, 1983.		
• •	and the second of the second o		
•••	ALLEGO 15 - 10 - 87		
	My Our address for service is Messrs. Edwd. Waters & Sons, Patent Attorneys.		
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Melboi	DATED this 19th day of July, 1984		
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(5) Sirna-	HOECHST AKTIENGESELLSCHAFT		
ture (s) of Applicant (S) or			
Seal of	Same but also		

JAMES MURRAY

# COMMONWEALTH OF AUSTRALIA Patents Act 1952

DECLARATION IN SUPPORT OF A CONVENTION APPLICATION UNDER PART XVI. FOR A PATENT.

In support of the Convention application made under Part XVI. of the Patents Act 1952 by HOECHST AKTIENGESELLSCHAFT of 45, Brüningstrasse, D-6230 Frankfurt/Main 80, Federal Republic of Germany for a patent for an invention entitled: "PHARMACEUTICAL PRODUCTS WITH PROTRACTED RELEASE WHICH CONTAIN REGULATORY PEPTIDES, AND PROCESSES FOR THEIR PREPARATION"

We Karl-Hermann Meyer-Dulheuer, 31 Höhenstraße, D-6242 Kronberg/Taunus, Otto Klein, 24 Johann-Strauß-Straße, D-6233 Kelkheim (Taunus); Federal Republic of Germany do solemnly and sincerely declare as follows:

- 1. We are authorized by HOECHST AKTIENGESELLSCHAFT the applicant for the patent to make this declaration on its behalf.
- 2. The basic applications as defined by Section 141 of the Act XXXX were made in the Federal Republic of Germany under No. P 33 27 856.3 on August 2, 1983 and under No. P 33 36 197.5 byxHOECHSTXAKTENGESELNSGHAKTX on October 5, 1983 by HOECHST AKTIENGE-SELLSCHAFT
- a) Wolfgang König, 25 Eppsteiner Straße, D-6238 Hofheim am Taunus b) Heinz-Rüdiger Seidel, 15 Im Kirschenfeld, D-6370 Oberursel/Taunus
  - c) Jürgen Kurt Sandow, 22 Am Haideplacken, D-6240 Königstein/Taunus
  - a) c) Federal Republic of Germany

XEXare the actual inventor(s) of the invention and the facts upon HOECHST AKTIENGESELLSCHAFT which

is entitled to make the application are as follows: HOECHST AKTIENGESELLSCHAFT The said

is the assignee of the said Wolfgang König, Heinz-Rüdiger Seidel and Jürgen Kurt Sandow

4. The basic applications referred to in paragraph 2 of this Declaration was the first application made in a Convention country in respect of the invention the subject of the application. DECLARED at Frankfurt/Main, Federal Republic of Germany 16th day of July 1984 this

To the Commissioner of Patents

Hoechel

Aktiengesellschaft

Mes Mens-Vellener Prokurist

Authorized signatory

(ppd.Meyer-Dulheuer) (i.V.Klein)

PAT 510

COMMONWEALTH OF AUSTRALIA

PATENTS ACT 1952-69

#### SPECIFICATION COMPLETE

(ORIGINAL)

Class Int. Class

Complete Specification Lodged:

Lodged:

Application Number:

Accepted:

Published:

Priority:

Related Art:

No. of the legal

Name of Applicant :

HOECHST AKTIENGESELLSCHAFT

31399/84

Address of Applicant: 45 Bruningstrasse, D-6230 Frankfurt/Main 80,

Federal REpublic of Germany.

Actual Inventor:

Address for Service:

EDWD. WATERS & SONS.

50 QUEEN STREET, MELBOURNE, AUSTRALIA, 3000.

Complete Specification for the invention entitled:

PHARMACEUTICAL PRODUCTS WITH PROTRACTED RELEASE WHICH CONTAIN REGULATORY PEPTIDES, AND PRUCESSES FOR THEIR PREPARTATION

The following statement is a full description of this invention, including the best method of performing it known to :-

The invention relates to a formulation, which can be implanted, of regulatory peptides and of analogs thereof with protracted release, and to processes for the preparation of the implants.

It has already been reported that, during in vitro experiments, the active compound is released slowly from matrix tablets containing 7-hydroxyethyltheophylline, as the active compound, and poly-D(-)-3-hydroxybutyric acid, as the biologically degradable carrier material 10 (Pharm. Ind. 45, pages 525-527 (1983)).

It has furthermore been reported that the peptides are released slowly from medicaments containing peptides as the active compounds and biodegradable polymers as carrier substances. The carriers are chiefly synthetic polyesters of lactic acid and copolymers of lactic acid and glycolic acid (c.f. for example, European Patent Applications publication numbers 0,052,510 and 0,053,481) and synthetic amino acid polymers (c.f. U.S. Patent 4,351,337). The disadvantage of synthetic polymers is that residues of the polymerization catalyst must be reckoned with. Such residues are undesirable in medicaments, especially in implants.

It has now been found that naturally occurring polyhydroxybutyric acid is suitable as a carrier for 25 peptide-containing implants from which the active compound is released in a protracted manner.

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The invention thus relates to implants containing regulatory peptides or analogs thereof as the active compounds and naturally occurring poly-D-(-)-3-hydroxybuty-ric acid (PHB) of the formula

in which a represents a number between 500 fand 25,000, as the biologically degradable carrier.

In the statements made above and below, "peptides" means regulatory peptides and analogs thereof, as 10 well as physiologically acceptable salts thereof...

The invention furthermore relates to processes for the preparation of implants containing regulatory peptides or analogs thereof as active compounds, which comprise

- 15 1. dissolving the active compound in a low-molecular alcohol which has 1 to 4 carbon atoms and is optionally substituted by up to 3 fluorine atoms or in water or in a mixture of these solvents, mixing the solution with the poly-D-(-)-3-hydroxybutyric acid, drying the moist mate-
- 2. dissolving the poly-D(-)-3-hydroxybutyric acid in a halogenated aliphatic C<sub>1</sub>-C<sub>4</sub>-hydrocarbon, mixing the solution with a solution of the active compound in a low-motecular alcohol which has 1 to 4 carbon atoms and is optionally substituted by up to 3 fluorine atoms, subjecting the resulting solution to spray-drying and

pressing the dried cottonwool-like material, or

size.

3. dissolving the poly-D(-)-3-hydroxybutyric acid in a halogenated aliphatic C<sub>1</sub>-C<sub>4</sub>-hydrocarbon, suspending the active compound in this solution, pouring the suspension onto a suitable substrate, for example into a glass dish, evaporating off the solvent and, if appropriate, dividing up the resulting film into pieces of suitable

The resulting pressed pieces or films can be

10 ground and divided into various particle sizes by sieving.

The solid shaped articles can be implanted as such or,

after prior comminution, injected in the form of

suspensions.

The regulatory peptides (naturally occurring,

15 synthetic and semi-synthetic), which can also be used in
the form of salts, are soluble in water and low-molecular
alcohols which are optionally substituted by fluorine.
Possible alcohols are, in particular, methanol and trifluoroethanol. Particularly suitable solvents for the

20 PHB are fluorinated and chlorinated hydrocarbons, such as
methylene chloride, chloroform and 1,1,2-trichloro-1,2,2trifluoroethane, methylene chloride and chloroform being
especially suitable.

The PHB is synthesized by bacteria, such as, for 25 example, by Alcaligenes eutrophus. It is obtained in the form of small globules in the bacteria and can be greatly increased in concentration by corresponding conditions in the bacteria and easily isolated therefrom (c.f. Pharma.

Ind.  $\underline{45}$ , pages 525-527). Each unit of PHB consists of optically pure D-(-)-3-hydroxybutyric acid.

Biological degradation of PHB in vivo proceeds relatively slowly and contributes little to the release 5 of an active compound from an implant. The release is chiefly controlled by the surface of the implant and the amount of active compound contained therein. If very small amounts of a peptide are to be released for a relatively long time, an impant with a small surface area and 10 a low peptide centent, for example in the form of pressed pieces, is advisable. The release from the pressed piece can be further reduced by coating the implant completely or partly with a layer of PHB or other biologically degradable polymers, such as polylactic acid or polylactic acid/polyglycolic acid copolymers or with polymers such as ethylcellulose, poly(meth)acrylic acid derivatives or polydimethylsiloxanes.

An essentially uniform release of poptides for up to one year can be achieved with such impants. The im
20 plants can easily be removed by operation, if the treatment is to be discontinued.

Whilst the implantation tablets prepared according to method 1 release a relatively constant amount of a regulatory peptide from the start, the implants obtained 25 according to method 2 release a relatively large amount of peptide in the first days and then release constant small amounts. Good adaptation to the desired pattern of release of the active compound is thus possible with the

implants according to the invention.

These slow rates of release are surprising when compared with the rates of release of about 40 days, which in contrast are rapid, obtained with the copolymers of lactic acid and glycolic acid (c.f. European Patent Application publication number 0,058,481).

Very small tablets or other small shaped articles throughout which the entire dose is distributed are suitable as implants for shorter release times. As a result 10 of the substantially larger surface area which a large number of medicinal carriers have in comparison with a single shaped piece, the release is more rapid. Small particles which can be prepared by comminution of tablets and films are preferred. They can be injected, 15 after suspension in a suitable medium. The particle size should not exceed a particular value here and is advantageously in the range from 0.1 to 200 pm.

Physiological saline solution in which, for example, 1% of hydroxypropylmethylcellulose (Methocel R 20 E5), carboxymethylcellulose (Blanose R 7LF) or polyethylene glycol sorbitan monostearate (Tween R 20) is dissolved can be used for suspension and injection of the particles.

Regulatory peptides are endogenous peptides which 25 have a physiological action, they are also called peptide hormones, which, depending on the site of synthesis or release, are classified into, for example, peptide hormones of the hypothalamus, of the pituitary gland, of the

gastrointestinal tract or of the thyroid gland. This classification is inappropriate today, since it is known that the so-called peptide hormones are not produced only at one site in the body and, in addition to their endocrine mode of action, can also act in a paracrine or neurocrine manner.

Classification of these peptides according to indications is also inappropriate, since they can develop the most diverse therapeutic activities, depending on the 10 site of action and the dose.

Examples of representative regulatory peptides which the implants according to the invention can contain are oxytocin, vasopressin, thyroliberin the anorexigenic peptide, gonadoliberin, calcitonin, parathornone the

- 15 epidermal growth factor, secretin the vasoactive intestinal peptide, somatoliberin the gastrin-inhibiting or glucose-dependent insulinotropic peptide, glucagon the pancreatic spasmolytic peptide, somatostatin, bombosin the gastrin-releasing peptide, motilin, neutrotensin,
- 20 substance P, sauvagin, conticoliberin, unotensin 1 and II, angiotensin I and II, bradykinin, conticotropin, encephalins, dynorphin, dermophin, casomerhins, gastrin, cholecystokin, cerulein, thymus factors, interferons, insulin, growth hormone and prolactin.
- The highly active analogs of gonadoliberin, such as, for example,  $[D-Ser(Bu^{\dagger})^{6}]$ gonadoliberin-(1-9)nona-peptide-ethylamide (buserelin, Drugs of the Future 4, 1979, pages 175-77, 8, 1983, page 254),  $[D-Trp^{6}]$

gonadoliberin (Drugs of the Future 3, 1978, pages 645-646), ED-Trp<sup>6</sup>Jgonadoliberin(1-9)-nonapeptide-ethylamide (Drugs of the Future 7, 1982, pages 637-642), ED-Leu<sup>6</sup>Jgonadoliberin(1-9)-nonapeptide-ethylamide (Drugs of the

5 Future 7, 1982, pages 882-886), [D-Ser(But)6, AzaGly<sup>10</sup>] gonadoliberin (Drugs of the Future <u>5</u>, 1980, pages 191-192; <u>8</u>, 1983, pages 364-365), [D-Trp<sup>6</sup>, N-McLeu<sup>7</sup>] gonadoliberin-(1-9)-nonapeptide-ethylamide (Drugs of the Future 8, 1983, pages 347-350), [D-X-aminoadipic acid &-tert.-butyl

10 ester<sup>6</sup>] gonadoliberin-(1-9)-nonapeptide-ethylamide (German Offenlogungsschrift 3,020,941), [D-Lys(Boc)<sup>6</sup>] gonadoliberin-(1-9)-nonapeptide-ethylamide (German Patent 2,438,350), [D-3-(2,4,6-trimethylphenyl)-Ala<sup>6</sup>] gonadoliberin and [D-3-(2-naphthyl)-Ala<sup>6</sup>] gonadoliberin (J. Med. Chem. <u>25</u>, 1982, pages 795-801), are of particular importance.

In a high dosage, these peptides reduce the

plasma levels of lutropin and follitropin and hence those of the gonadal steroids testosterone and oestradiol.

These derivatives can therefore be used for hormone~

20 dependent tumors, such as, for example, carcinoma of the prostate or of the breast, and also for endometriosis and pubertas preacox in children. Continuous uniform release of the active compound is particularly important for this therapy. With the formulation according to the invention,

25 the necessary amount of the active compound, which would otherwise have to be administered parenterally or intranasally 2-3 times daily, can be released for weeks or months with a single administration. Use on older persons

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and children is thus particularly safe from administration errors (compliance).

Ano her important use of the formulation according to the invention is the protracted release of somatostatin 5 and somatostatin analogs, which can be used in all cases where somatostatin infusions exhibit an advantageous effect; for example for hemorrhages of the gastrointestinal tract, for gastric ulcers, for the treatment of tumors which produce hormones which can be inhibited by 10 somatostatin, such as, for example, for Zollinger-Ellison syndrome or Verner-Morrison syndrome, or for tumors which produce insulin or glucagon, for hormone-dependent tumors, if the corresponding hormones can be inhibited by sometostatin, for certain types of leukenia, for metabolism dis-15 orders with increased hormone levels which can be inhibited by sometostatin, such as, for example, rheumatoid arthritis, where the plasma insulin and growth hormone are too high, for acromegaly or psoriasis, for Diabetes mellitus (inhibition of glucagon), for chondrosarcoma and 20 for states of shock.

Highly active analogs of sometostatin are compounds in which, for example,  ${\sf Trp}^B$  is replaced by D-Trp or 5-F-D-Trp, or shortened cyclic compounds, such as, for example,

LPro-Phe-D-Trp-Lys-Thr-Pho-

(Nature 292, 1981, page 55) or

25

H-D-Phe-Cys-Phe-D-Trp-Lys-Thr-Cys-Thr-ol

(Life Sci. 31, 1982, pages 1,133-1,140).

Therapy of upper gastrointestinal hemorrhages with secretin infusions can also be simplified by the new galenical formulation.

The ratio of active compound to carrier material 5 can vary within wide limits. Since the peptides are administered in low dosages, the amount of carrier material in the implants is relatively high (for example 100 : 1 to 10,000 : 1).

## Example 1:

- 2.5 g of PHB were moistened with a methanolic solution containing 2.875 mg of buserelin acetate (corresponding to 2.5 mg of buserelin) and mixed thoroughly. The moist material was dried in vacuo, with shaking. The procedure was repeated several times with pure methanol.
- 15 The dry mixture was pressed to tablets (implants) weighing 50 mg and containing 50 µg of buserelin.

## Example 2:

2.875 mg of buserelin acetate (corresponding to 2.5 mg of buserelin) were dissolved in 30 ml of methanol, 20 and 2.5 g of PHB were dissolved in 70 ml of chloroform. The two solutions were combined and subjected to spraydrying. A flaky powder was obtained, from which tablets weighing 50 mg and containing 50 µg of buserelin were pressed.

## Example 3:

The pressed pieces prepared under Example 1 or 2 were micronized. The resulting particles were divided into particle size ranges up to about 200 µm by sieving.

5 The fractions were suspended in physiological saline solution with 1% of carboxymethylcallulose in a concentration of 50 mg/ml for injection.

# Example 4:

2.5 g of PHB were dissolved in 25 g of chloroform.

10 287.5 mg of buserelin acetate (corresponding to 250 mg of buserelin) were suspended in this solution. The suspension was poured into a Petri dish. The solvent was allowed to evaporate slowly. A film was formed, and divided into flakes 1 cm<sup>2</sup> in size, containing about 5 mg 15 of buserelin.

#### Example 5:

# Biological testing of the formulations on rats

Two implantation materials of PRB and a copolymer of lactic acid and glycolic acid (PLG) of identical 20 weight and size which had been prepared analogously to Example 1 were investigated. The materials were tested on adult rats weighing 400 g, the amount of peptide released each day being determined by pharmacokinetic detection by means of specific radioimmunoassay. In the 25 case of the PRB implant, a release of 0.203 ± 0.038 ng of buserelin per day was found. In contrast, a release of 1.075 ÷ 0.029 ng of buserelin/day was found for the PLG implant. The total duration of the release of the peptide

was calculated from the cumulative rate of release. It is 221 ± 29 days for the PHB implant and 46.5 ± 1.2 days for the PLG implant. The PHB implant material is thus considerably more suitable for long-term release of pep-5 tides than the copolymer of lactic acid and glycolic acid (50:50) used for comparison.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS: RAXENIXXEKAIXX

1. An implant containing a regulatory peptide or one of its analogs as the active compound and naturally occurring poly-D(-)-3-hydroxybutyric acid of the formula

$$\frac{c_{H^3}}{c_{H^{-CH}-CH^5-CO^{-1}}}$$

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- 2. Implant as claimed in claim 1, which contains buserelin(acetate) as the active compound.
- 3. A process for the preparation of an implant as claimed in claim 1, which comprises
- 1. dissolving the active compound in a low-molecular alcohol which has 1 to 4 carbon atoms and is optionally substituted by up to 3 fluorine atoms or in water or in a mixture of these two solvents, mixing the solution with the poly-D-(-)-3-hydroxybutyric acid, drying the moist material and pressing the product, or
- 2. dissolving the poly-D(-)-3-hydroxybutyric acid in a halogenated aliphatic C<sub>1</sub>-C<sub>4</sub>-hydrocarbon, mixing the solution with a solution of the active compound in a low-molecular alcohol which has 1 to 4 carbon atoms and is optionally substituted by up to 3 fluorine atoms, subjecting the resulting solution to spray-drying and pressing the dried material, or
- 3. dissolving the poly-D(-)-3-hydroxybutyric acid in

a halogenated aliphatic C<sub>1</sub>-C<sub>4</sub>-hydrocarbon, suspending the active compound in this solution, pouring the suspension onto a suitable substrate, evaporating off the solvent and, if appropriate, dividing up the resulting film into pieces of suitable size.

- 4. The process as claimed in claim 3, wherein the pressed piece or film is comminuted in a further step and suspended in a solvent suitable for injection purposes.
- 5. The process as claimed in claim 3, wherein the active compound is dissolved in methanol.
- 6. The process as claimed in claim 3, wherein the carrier substance is dissolved in chloroform.

DATED THIS 31st day of July, 1984

HUECHST AKTIENGESLLSCHAFT

EDWD. WATERS & SUNS. PATENT ATTURNEYS, 50 QUEEN STREET, MELBOURNE. VIC. 3000.

- (12) PATENT ABRIDGEMENT (11) Document No. AU-B-31399/84
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- (51)4 International Patent Classification A61K 047/00 A61K 037/02
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- (74) Attorney or Agent EDWD. WATERS & SONS
- (54) Title
  PHARMACEUTICAL PRODUCTS WITH PROTRACTED RELEASE WHICH
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- 1. An implant containing a regulatory peptide or one of its analogs as the active compound and naturally occurring poly-D(-)-3-hydroxybutyric acid of the formula

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(CONVENTION. By one or more persons and/or a Company.)

COMMONWEALTH OF AUSTRALIA

Patents Act . 952-1969

# CONVENTION APPLICATION FOR A PATENT

(1) Here insert (in full) Name or Names of Applicant or Applicants, followed by Address (es).	Me HOECHST AKTIENGESELLSCHAFT,  of 45 Bruningstrasse,  D-6230 Frankfurt am Main 80,  Federal REpublic of Germany.
• • •	
•(2) Here insert Title • or invention.	hereby apply for the grant of a Patent for an invention entitled: (2)
••••	CONTAIN REGULATORY PEPTIDES, AND PROCESSES FOR THEIR
• • •	PREPARATION.
(3) Here insert number(s) of basic application(s)  ***  **(a) Here insert Name of basic Country or Countries, and basic date or edates	which is described in the accompanying complete specification. This application is a  Convention application and is based on the application numbered (3)  P 33 27 856.3 and P 33 36 197.5  for a patent or similar protection made in (4) Federal Republic of  Germany on 2nd August, 1983 and 5th October, 1983.
• •	ALIMAN 15-10-87
LODGED AT SU	My Our address for service is Messrs. Edwd. Waters & Sons, Patent Attorneys.  3-0:500Queen Street, Melbourne, Victoria, Australia.
(5) Sirna- ture (5) Cf	HOECHST AKTIENGESELLSCHAFT
Applicant (S) Or Seal of Company and Stanatures of its Officers as prewrited by its Articles of Association	JAMES MURRAY

JAMES MURRAY

# COMMONWEALTH OF AUSTRALIA Patents Act 1952

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In support of the Convention application made under Part XVI. of the Patents Act 1952 by HOECHST AKTIENGESELLSCHAFT of 45, Brüningstrasse, D-6230 Frankfurt/Main 80, Federal Republic of Germany for a patent for an invention entitled:

"PHARMACEUTICAL PRODUCTS WITH PROTRACTED RELEASE WHICH CONTAIN REGULATORY PEPTIDES, AND PROCESSES FOR THEIR PREPARATION"

We Karl-Hermann Meyer-Dulheuer, 31 Höhenstraße, D-6242 Kronberg/Taunus, Otto Klein, 24 Johann-Strauß-Straße, D-6233 Kelkheim (Taunus); Federal Republic of Germany do solemnly and sincerely declare as follows:

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- a) Wolfgang König, 25 Eppsteiner Straße, D-6238 Hofheim am Taunus
  - b) Heinz-Rüdiger Seidel, 15 Im Kirschenfeld, D-6370 Oberursel/Taunus
  - c) Jürgen Kurt Sandow, 22 Am Haideplacken, D-6240 Königstein/Taunus
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Isyare the actual inventor(s) of the invention and the facts upon HOECHST AKTIENGESELLSCHAFT which

is entitled to make the application are as follows: HOECHST AKTIENGESELLSCHAFT The said

is the assignee of the said Wolfgang König, Heinz-Rüdiger Seidel • and Jürgen Kurt Sandow

4. The basic applications referred to in paragraph 2 of this Declaration want the first application made in a Convention country in respect of the invention the subject of the application. DECLARED at Frankfurt/Main, Federal Republic of Germany 16th day of July 1984

To the Commissioner of Patents

Hoechsi

Aktiengesellschaft

Authorized signatory

Me Mega-Villeurer Prokurist (ppd.Meyer-Dulheuer)

(i.V.Klein)

**PAT 510** 

567572...

COMMONWEALTH-OF AUSTRALIA

PATENTS ACT 1952-69

# COMPLETE SPECIFICATION

(ORIGINAL)

Class

Int. Class

Application Number:

Lodged:

Complete Specification Lodged:

Accepted:

Published:

Priority:

Related Art:

31399/84

This try ment contains the contains of a contain of the contains

Name of Applicant :

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Address of Applicant:

45 Bruningstrasse, D-6230 Frankfurt/Main 80,

Federal RÉpublic of Germany.

Actual Inventor:

Address for Service :

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50 QUEEN STREET, MELBOURNE, AUSTRALIA, 3000.

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It has now been found that naturally occurring polyhydroxybutyric acid is suitable as a carrier for 25 peptide-containing implants from which the active compound is released in a protracted manner.

The invention thus relates to implants containing regulatory peptides or analogs thereof as the active compounds and naturally occurring poly-D-(-)-3-hydroxybuty-ric acid (PHB) of the formula

5

in which a represents a number between 500 and 25,000, as the biologically degradable carrier.

In the statements made above and below, "peptides" means regulatory poptides and analogs thereof, as 10 well as physiologically acceptable salts thereof...

The invention furthermore relates to processes for the preparation of implants containing regulatory peptides or analogs thereof as active compounds, which comprise

- 15 1. dissolving the active compound in a low-molecular alcohol which has 1 to 4 carbon atoms and is optionally substituted by up to 3 fluorine atoms or in water or in a mixture of these solvents, mixing the solution with the poly-D-(-)-3-hydroxybutyric acid, drying the moist mate-
- 2. dissolving the poly-D(-)-3-hydroxybutyric acid in a halogenated aliphatic C<sub>1</sub>-C<sub>4</sub>-hydrocarbon, mixing the solution with a solution of the active compound in a low-molecular alcohol which has 1 to 4 carbon atoms and is optionally substituted by up to 3 fluorine atoms, subjecting the resulting solution to spray-drying and

pressing the dried cottonwool-like material, or

size.

3. dissolving the poly-D(-)-3-hydroxybutyric acid in a halogenated aliphatic C<sub>1</sub>-C<sub>4</sub>-hydrocarbon, suspending the active compound in this solution, pouring the suspension onto a suitable substrate, for example into a glass dish, evaporating off the solvent and, if appropriate, dividing up the resulting film into pieces of suitable

The resulting pressed pieces or films can be

10 ground and divided into various particle sizes by sieving.

The solid shaped articles can be implanted as such or,

after prior comminution, injected in the form of

suspensions.

The regulatory peptides (naturally occurring,

15 synthetic and semi-synthetic), which can also be used in
the form of salts, are soluble in water and low-molecular
alcohols which are optionally substituted by fluorine.
Possible alcohols are, in particular, methanol and trifluoroethanol. Particularly suitable solvents for the

20 PHB are fluorinated and chlorinated hydrocarbons, such as
methylene chloride, chloroform and 1,1,2-trichloro-1,2,2trifluoroethane, methylene chloride and chloroform being
especially suitable.

The PHB is synthesized by bacteria, such as, for 25 example, by Alcaligenes eutrophus. It is obtained in the form of small globules in the bacteria and can be greatly increased in concentration by corresponding conditions in the bacteria and easily isolated therefrom (c.f. Pharma.

Ind. 45, pages 525-527). Each unit of PHB consists of optically pure D-(-)-3-hydroxybutyric acid.

Biological degradation of PHB in vivo proceeds relatively slowly and contributes little to the release 5 of an active compound from an implant. The release is chiefly controlled by the surface of the implant and the amount of active compound contained therein. If very small amounts of a poptide are to be released for a relatively long time, an impant with a small surface area and 10 a low peptide centent, for example in the form of pressed pieces, is advisable. The release from the pressed piece can be further reduced by coating the implant completely or partly with a layer of PHB or other biologically degradable polymers, such as polylactic acid or polylactic acid/polyglycolic acid copolymers or with polymers such as ethylcellulose, poly(meth)acrylic acid derivatives or polydimethylsiloxanes.

An essentially uniform release of poptides for up to one year can be achieved with such impants. The im
20 plants can easily be removed by operation, if the treatment is to be discontinued.

Whilst the implantation tablets prepared according to method 1 release a relatively constant amount of a regulatory peptide from the start, the implants obtained 25 according to method 2 release a relatively large amount of peptide in the first days and then release constant small amounts. Good adaptation to the desired pattern of release of the active compound is thus possible with the

implants according to the invention.

These slow rates of release are surprising when compared with the rates of release of about 40 days, which in contrast are rapid, obtained with the copolymers of lactic acid and glycolic acid (c.f. European Patent Application publication number 0,058,481).

Very small tablets or other small shaped articles throughout which the entire dose is distributed are suitable as implants for shorter release times. As a result 10 of the substantially larger surface area which a large number of medicinal carriers have in comparison with a single shaped piece, the release is more rapid. Small particles which can be prepared by comminution of tablets and films are preferred. They can be injected, 15 after suspension in a suitable medium. The particle size should not exceed a particular value here and is advantageously in the range from 0.1 to 200 µm.

Physiological saline solution in which, for example, 1% of hydroxypropylmathylcellulose (Methocel R 20 E5), carboxymethylcellulose (Blanose R 7LF) or polyethylene glycol sorbitan monostearate (Tween R 20) is dissolved can be used for suspension and injection of the particles.

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Regulatory peptides are endogenous peptides which 25 have a physiological action, they are also called peptide hormones, which, depending on the site of synthesis or release, are classified into, for example, peptide hormones of the hypothalamus, of the pituitary gland, of the

gastrointestinal tract or of the thyroid gland. This classification is inappropriate today, since it is known that the so-called peptide hormones are not produced only at one site in the body and, in addition to their endocrine made of action, can also act in a paracrine or neurocrine manner.

Classification of these peptides according to indications is also inappropriate, since they can develop the most diverse therapeutic activities, depending on the 10 site of action and the dose.

Examples of representative regulatory peptides which the implants according to the invention can contain are oxytocin, vasopressin, thyroliberin the anorexigenic peptide, gonadoliberin, calcitonin, parathornous the

- 15 epidermal growth factor, secretin the vasozctive intestinal peptide, sometoliberin the gastrin-inhibiting or glucose-dependent insulinotropic peptide, glucagon the pancreatic spasmolytic peptide, sometostatin, bombosin the gastrin-releasing peptide, motilin, neutrotensin,
- 20 substance P, sauvagin, corticoliberin, urotensin 1 and II, angiotensin I and II, bradykinin, corticotropin, encephalins, dynorphin, dermophin, casomorhins, gastrin, cholecystokin, cerulein, thymus factors, interferons, insulin, growth hormone and prolactin.
- The highly active analogs of gonadoliberin, such as, for example, ED-Ser(Bu<sup>t</sup>)<sup>6</sup>Jgonadoliberin-(1-9)nona-peptide-ethylamide (buserelin, Drugs of the Future 4, 1979, pages 175-77, 8, 1983, page 254), ED-Trp<sup>6</sup>J

gonadoliberin (Drugs of the Future 3, 1978, pages 645-646), ED-Trp<sup>6</sup>Jgonadoliberin(1-9)-nonapeptide-ethylamide (Drugs of the Future 7, 1982, pages 637-642), ED-Leu<sup>6</sup>Jgonadoliberin(1-9)-nonapeptide-ethylamide (Drugs of the

5 Future 7, 1982, pages 882-886), [D-Ser(But)6, AzaGly10];
gonadoliberin (Drugs of the Future 5, 1980, pages 191-192;
8, 1983, pages 364-365), [D-Trp6, N-MeLeu7] gonadoliberin(1-9)-nonapeptide-ethylamide (Drugs of the Future 8, 1983, pages 347-350), [D-χ-aminoadipic acid δ-tert.-butyl

10 ester6] gonadoliberin-(1-9)-nonapeptide-ethylamide (German Offenlegungsschrift 3,020,941), [D-Lys(Boc)6] gonadoliberin(1-9)-nonapeptide-ethylamide (German Patent 2,438,350),
[D-3-(2,4,6-trimethylphenyl)-Ala6] gonadoliberin and
[D-3-(2-naphthyl)-Ala6] gonadoliberin (J. Med. Chem. 25,

15 1982, pages 795-801), are of particular importance.

•••••

In a high dosage, these peptides reduce the plasma levels of lutropin and follitropin and hence those of the gonadal steroids testosterone and oestradiol.

These derivatives can therefore be used for hormone—

20 dependent tumors, such as, for example, carcinoma of the prostate or of the breast, and also for endometriosis and pubertas preacox in children. Continuous uniform release of the active compound is particularly important for this therapy. With the formulation according to the invention,

25 the necessary amount of the active compound, which would otherwise have to be administered parenterally or intranasally 2-3 times daily, can be released for weeks or months with a single administration. Use on older persons

and children is thus particularly safe from administration errors (compliance).

Ano her important use of the formulation according to the invention is the protracted release of somatostatin 5 and somatostatin analogs, which can be used in all cases where somatostatin infusions exhibit an advantageous effect; for example for hemorrhages of the gastrointestinal tract, for gastric ulcers, for the treatment of tumors which produce hormones which can be inhibited by 10 somatostatin, such as, for example, for Zollinger-Ellison syndrome or Verner-Morrison syndrome, or for tumors which produce insulin or glucagon, for hormone-dependent tumors, if the corresponding hormones can be inhibited by someton statin, for certain types of Leukemia, for metabolism dis-15 orders with increased hormone levels which can be inhibited by somatostatin, such as, for example, rheumatoid arthritis, where the plasma insulin and growth hormone are too high, for acromegaly or psoriasis, for Diabetes mellitus (inhibition of glucagon), for chondrosarcoma and 20 for states of shock.

Highly active analogs of sometostatin are compounds in which, for example,  ${\sf Trp}^{\sf B}$  is replaced by D-Trp or 5-F-D-Trp, or shortened cyclic compounds, such as, for example,

Pro-Phe-D-Trp-Lys-Thr-Phe-

(Nature 292, 1981, page 55) or

25

H-D-Phe-Cys-Phe-D-Trp-Lys-Thr-Cys-Thr-ol (Life Sci. 31, 1982, pages 1,133-1,140).

Therapy of upper gastrointestinal hemorrhages with secretin infusions can also be simplified by the new galenical formulation.

The ratio of active compound to carrier material

5 can vary within wide limits. Since the peptides are
administered in low dosages, the amount of carrier material in the implants is relatively high (for example

100 : 1 to 10,000 : 1).

## Example 1:

- 2.5 g of PHB were moistened with a methanolic solution containing 2.875 mg of buserelin acetate (corresponding to 2.5 mg of buserelin) and mixed thoroughly. The moist material was dried in vacuo, with shaking. The procedure was repeated several times with pure methanol.
- ing 50 mg and containing 50 µg of buserelin.

#### Example 2:

2.875 mg of buserelin acetate (corresponding to 2.5 mg of buserelin) were dissolved in 30 ml of methanol, 20 and 2.5 g of PHB were dissolved in 70 ml of chloroform. The two solutions were combined and subjected to spraydrying. A flaky powder was obtained, from which tablets weighing 50 mg and containing 50 µg of buserelin were pressed.

## Example 3:

The pressed pieces prepared under Example 1 or 2 were micronized. The resulting particles were divided into particle size ranges up to about 200  $\mu m$  by sieving.

5 The fractions were suspended in physiological saline solution with 1% of carboxymethylcallulose in a concentration of 50 mg/ml for injection.

# Example 4:

2.5 g of PHB were dissolved in 25 g of chloroform.

10 287.5 mg of buserelin acetate (corresponding to 250 mg of buserelin) were suspended in this solution. The suspension was poured into a Petri dish. The solvent was allowed to evaporate slowly. A film was formed, and divided into flakes 1 cm<sup>2</sup> in size, containing about 5 mg 15 of buserelin.

### Example 5:

# Biological testing of the formulations on rats

Two implantation materials of PHB and a copolymer of lactic acid and glycolic acid (PLG) of identical 20 weight and size which had been prepared analogously to Example 1 were investigated. The materials were tested on adult rats weighing 400 g, the amount of peptide released each day being determined by pharmacokinetic detection by means of specific radioimmunoassay. In the 25 case of the PHB implant, a release of 0.203 ± 0.038 ng of buserelin per day was found. In contrast, a release of 1.075 ÷ 0.029 ng of buserelin/day was found for the PLG implant. The total duration of the release of the peptide

was calculated from the cumulative rate of release. It is 221 ± 29 days for the PHB implant and 46.5 ± 1.2 days for the PLG implant. The PHB implant material is thus considerably more suitable for long-term release of pep-5 tides than the copolymer of lactic acid and glycolic acid (50:50) used for comparison.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. An implant containing a regulatory peptide or one of its analogs as the active compound and naturally occurring poly-D(-)-3-hydroxybutyric acid of the formula

$$\frac{c_{H^3}}{c_{H^3}}$$

from  $f_0$  in which is represents a number  $f_0$  between 500 and 25,000, as the biologically degradable carrier.

- 2. Implant as claimed in claim 1, which contains buserelin(acetate) as the active compound.
- 3. A process for the preparation of an implant as claimed in claim 1, which comprises
- 1. dissolving the active compound in a low-molecular alcohol which has 1 to 4 carbon atoms and is optionally substituted by up to 3 fluorine atoms or in water or in a mixture of these two solvents, mixing the solution with the poly-D-(-)-3-hydroxybutyric acid, drying the moist material and pressing the product, or
- 2. dissolving the poly-D(-)-3-hydroxybutyric acid in a halogenated aliphatic C<sub>1</sub>-C<sub>4</sub>-hydrocarbon, mixing the solution with a solution of the active compound in a low-molecular alcohol which has 1 to 4 carbon atoms and is optionally substituted by up to 3 fluorine atoms, subjecting the resulting solution to spray-drying and pressing the dried material, or
- 3. dissolving the poly-D(-)-3-hydroxybutyric acid in

a halogenated aliphatic C<sub>1</sub>-C<sub>4</sub>-hydrocarbon, suspending the active compound in this solution, pouring the suspension onto a suitable substrate, evaporating off the solvent and, if appropriate, dividing up the resulting film into pieces of suitable size.

- 4. The process as claimed in claim 3, wherein the pressed piece or film is comminuted in a further step and suspended in a solvent suitable for injection purposes.
- 5. The process as claimed in claim 3, wherein the active compound is dissolved in methanol.
- 6. The process as claimed in claim 3, wherein the carrier substance is dissolved in chloroform.

DATED IHIS 31st day of July, 1984

HUECHST AKTIENGESLLSCHAFT

EDWD. WATERS & SUNS. PATENT ATTURNEYS, 50 QUEEN STREET, MELBOURNE. VIC. 3000.

(19) At

(54)	REGULATORY PEPTIDE IN POLY HY BIODEGRADABLE CARRIER		ACID AS A
(71)	HOECHST AKTIENGESELLSCHAFT		
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(51)3	.61K 47/00 A61K 37/02		
172)	MOI GIVEN		
¥74)			
(57)	. Implant includes tablet	s, flakes an	d injections
Claim			•

1. An implant containing a regulatory peptide or one of its analogs as the active compound and naturally occurring poly-D(-)-3-hydroxybutyric acid of the formula

in which a represents a number between 500 and 25,000, as the biologically degradable carrier.

#### COMMONWEALTH OF AUSTRALIA

PATENTS ACT 1952-69

# COMPLETE SPECIFICATION

(ORIGINAL)

Class

Int. Class

Application Number. Longest

Complete Specification Lodges:

Accepted: Published:

Priority

Related Art.

Name of Applicant:

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Federal REpublic of Germany.

Actual Inventor:

Address for Service:

EDWD. WATERS & SONS,

50 QUEEN STREET, MELBOURNE, AUSTRALIA, 3000.

Complete Specification for the invention entitled:

PHARMACEUTICAL PRODUCTS WITH PROTRACTED RELEASE WHICH CONTAIN REGULATORY PEPTIDES, AND PROCESSES FOR THEIR PREPARTATION

The following statement is a full description of this invention, including the best method of performing it known to :-

The invention relates to a formulation, which can be implanted, of regulatory peptides and of analogs thereof with protracted release, and to processes for the preparation of the implants.

or that already been reported that, during in vitro experiments, the active compound is released slowly from matrix tablets containing 7-hydroxyethyltheophylline, as the active compound, and poly-D(-)-3-hydroxybutyric acid, as the biologically degradable carrier material (Pherm. Ind. 45, pages 525-527 (1983)).

It has furthermore been reported that the peptides are released stouly from medicaments containing peptides as the active compounds and biodegradable polymers as carrier substances. The carriers are chiefly

- 15 synthetic polyesters of lactic acid and copolymers of lactic acid and glycolic acid (c.f. for example, European Patent Applications publication numbers 0,052,510 and 0,058,481) and synthetic amino acid polymers (c.f. U.S. Patent 4,351,337). The disadvantage of synthetic
- 20 polymers is that residues of the polymerization catalyst must be reckoned with. Such residues are undesirable in medicaments, especially in implants.

It has now been found that naturally occurring polyhydroxybutyric acid is suitable as a carrier for peptide-containing implants from which the active compound is released in a protracted manner.

The invention thus relates to implants containing regulatory peptides or analogs thereof as the active compounds and naturally occurring poly-P-(-)-3-hydroxybuty-ric acid (PHB) of the formula

in which is represents a number between 500 and 25,000, as the biologically degradable carrier.

In the statements made above and below, "peptides" means regulatory peptides and analogs thereof, as 10 well as physiologically acceptable salts thereof.

The invention furthermore relates to processes for the preparation of implants containing regulatory peptides or analogs thereof as active compounds, which comprise

- 15 1. dissolving the active compound in a low-molecular alcohol which has 1 to 4 carbon atoms and is optionally substituted by up to 3 fluorine atoms or in water or in a mixture of these solvents, mixing the solution with the poly-D-(-)-3-hydroxybutyric acid, drying the moist mate-
  - 2. dissolving the poly-D(+)-3-hydroxybutyric acid in a halogenated aliphatic  $C_1$ - $C_4$ -hydrocarbon, mixing the solution with a solution of the active compound in a low-molecular alcohol which has 1 to 4 carbon atoms and is
- optionally substituted by up to 3 fluorine atoms, subjecting the resulting solution to spray-drying and

pressing the dried cottonwool-like material, or

dissolving the poly-b(-)-3-hydroxybutyric acid in a hatogenated aliphatic C<sub>1</sub>-C<sub>4</sub>-hydrocarbon, suspending the active compound in this solution, pouring the suspension onto a suitable substrate, for example into a glass dish, evaporating off the softent, and, if appropriate, dividing up the resulting from into preces of suitable

size.

数据,提供的。 化性部形 : 20 The resulting pressed pieces or films can be 10 gro. nd and divided into various particle sizes by signing.

The solid shaped articles can be implanted as such or, after prior comminution, injected in the form of suspensions.

The regulatory peptides (naturally occurring,

15 synthetic and semi-synthetic), which can also be used in
the form of salts, are soluble in water and low-molecular
alcohols which are optionally substituted by fluorine.

Possible alcohols are, in particular, methanol and trifluoroethanol. Particularly suitable solvents for the

20 PHB are fluorinated and chlorinated hydrocarbons, such as
methylene chloride, chloroform and 1,1,2-trichloro-1,2,3trifluoroethane, methylene chloride and chloroform being
especially suitable.

The PHB is synthesized by bacteria, such as, for 25 example, by Alcaligenes eutrophus. It is obtained in the form of small globules in the bacteria and can be greatly increased in concentration by corresponding conditions in the bacteria and easily isolated therefrom (c.f. Pharma.

Ind. 45, pages 525-527). Each unit of PHB consists of optically pure D-(-)-3-hydroxybutyric acid.

elatively slowly and contributes little to the release of an active compound from an implant. The release is chiefly controlled by the surface of the implant and the amount of active compound contained therein. If very small amounts of a peptide are to be released for a relatively long time, an impant with a small surface area and low peptide content, for example in the form of pressed pieces, is advisable. The release from the pressed piece can be further reduced by coating the implant completely or partly with a layer of PHS or other biologically degradable polymers, such as polylactic acid or polylactic acid/polyglycolic acid copolymers or with polymers such as ethylcellulose, poly(meth)acrylic acid derivatives or polydimethylsiloxanes.

An essentially uniform release of peptides for up to one year can be achieved with such impants. The im20 plants can easily be removed by operation, if the treatment is to be discontinued.

Whilst the implantation tablets prepared according to method 1 release a relatively constant amount of a regulatory peptide from the start, the implants obtained according to method 2 release a relatively large amount of peptide in the first days and then release constant small amounts. Good adaptation to the desired pattern of release of the active compound is thus possible with the

implants according to the invention.

These slow rates of release are surprising when compared with the rates of release of about 40 days, which in contrast are rapid, obtained with the copolymers of lastic acid and glycolic acid (c.f. European Patent Application publication number 0,058,481).

throughout which the entire dose is distributed are suitable as implants for shorter release times. As a result 10 of the substantially larger surface area which a large number of medicinal carriers have in comparison with a single shaped piece, the release is more rapid. Small particles which can be prepared by comminution of tablets and films are preferred. They can be injected, 15 after suspension in a suitable medium. The particle size should not exceed a particular value here and is advantageously in the range from 0.1 to 200 µm.

Physiological saline solution in which, for example, 1% of hydroxypropylmathylcellulose (Methocel R 20 E5), carboxymethylcellulose (Blanose R 7LF) or polyethylene glycol sorbitan monostearate (Tween R 20) is dissolved can be used for suspension and injection of the particles.

Regulatory peptides are endogenous peptides which 25 have a physiological action, they are also called peptide hormones, which, depending on the site of synthesis or release, are classified into, for example, peptide hormones of the hypothalamus, of the pituitary gland, of the

gastrointestinal tract or of the thyroid gland. This classification is inappropriate today, since it is known that the so-called peptide hormones are not produced only at one site in the body and, in addition to their endocrine mode of action, can also act in a paracrine or neurocrine canner.

indications is also inapprepriate, since they can develop the most diverse therapeutic activities, depending on the 10 site of action and the dose,

Examples of representative regulatory peptides which the implants according to the invention can contain are oxytocin, vasopressin, thyroliberin the anorexigenic peptide, genadoliberin, calcitonin, parathormone the 15 epidermal growth factor, secretin the vasoactive intestinal peptide, somatoliberin the gastrin-inhibiting or glucose-dependent insulinotropic peptide, glucagon the pancreatic spasmolytic peptide, somatostatin, bombesin the gastrin-releasing peptide, motilin, neutrotensin, 20 substance P, sauvagin, corticoliberin, urotensin I and II, angiotensin I and II, bradykinin, corticotropin, encephalins, dynorphin, dermophin, casomorhins, gastrin, cholecystokin, cerulein, thymus factors, interferons, insulin, growth hormone and prolactin.

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The highly active analogs of gonadoliberin, such as, for example, ED-Ser(Bu<sup>t</sup>)<sup>6</sup>]gonadoliberin-(1-9)nona-peptide-ethylamide (buserelin, Drugs of the Future 4, 1979, pages 175-77, 8, 1983, page 254), ED-Trp<sup>6</sup>]

gonadoliberin (Brugs of the future 3, 1978, pages 645-646), ED-Irp<sup>6</sup>Igonadoliberin(1-9)-nonapeptide-ethy(amide (Drugs of the future 7, 1982, pages 637-642), ED-Leu<sup>6</sup>I gonadoliberin(1-9)-nonapeptide-ethy(amide (Erugs of the

5 Future 7, 1982, pages 882-886), ED-Ser(But), Azasty 19, gonadolimberin (Drugs of Line Future 5 2 4980, pages 191-7927 8, 1985, pages 364-365), ED-Trp?, N-Medeu/J conadolimberin (1-9)-nonaberinde enhytemade (Drugs of the Future 8, 1985, pages 347-350), ED-X-aminoadioic acid Seterit.-outyl

10 ester<sup>6</sup>] gonadoliberin-(i-9)%-nonapeptide-ethylamide (German Offenlegungsschrift 3,028, 246), Eb-Lys(Boc)<sup>6</sup>] gonadoliberin-(1-9)-nonapeptide-ethylamide (German Pâtent 2,436,356),

[D-3-(2,4,6-trimethylphenyl)-Ata<sup>6</sup>] gonadoliberin and

[D-3-(2-haphthyl)-Ala<sup>6</sup>] gonadoliberin (d. Ned. Chem. 25.

In a high tosage, these periodes reduce the plasma levels of lutropin and follitropin and hence those of the genedal steroids testosterone and oestradiol.

These derivatives can therefore be used for hormone—

20 dependent tumors, such as, for example, carcinoma of the prostate or of the breast, and also for endometriosis and pubertas preacox in children. Continuous uniform release of the active compound is particularly important for this therapy. With the formulation according to the invention,

25 the necessary amount of the active compound, which would otherwise have to be administered parenterally or intranasally 2-3 times daily, can be released for weeks or months with a single administration. Use on older persons

and children is thus particularly safe from administration errors (compliance).

Another important use of the formulation according to the invention is the protracted release of somatostatin 5 and sematestatin analogs, which can be used in all cases where sometostatio infusions exhibit an advantageous effect; for example for hemorrhages of the gastrointestinal tract, for gestric ulcers, for the treatment of tumors which produce hormones which can be inhibited by 10 sometostatin, such as, for example, for Zollinger-Ellison syndrone or Merner-Morrison syndrone, or for tumors which produce insulin or glucagon, for hormone-dependent tumors, if the corresponding hormones can be inhibited by somatostatin, for certain types of leukemia, for metabolism dis-15 orders with increased hormone levels which can be inhibited by somatostatio, such as, for example, rheumatoid arthritis, where the plasma insulin and growth hormone are too high, for acromegaly or psoriasis, for Diabetes mellitus (inhibition of glucagon), for chondrosarcoma and 20 for states of shock.

Highly active analogs of somatostatin are compounds in which, for example, Trp<sup>8</sup> is replaced by D-Trp or 5-F-D-Trp, or shortened cyclic compounds, such as, for example,

Pro-Pho-D-Trp-Lys-Thr-Phe-

(Nature 292, 1981, page 55) or

25

H-D-Phe-Cys-Phe-D-Trp-Lys-Thr-Cys-Thr-ol

(Life Sci. 31, 1982, pages 1,133-1,140).

Therapy of upper gastroistestimal hemorr' ages with secretin infusions can also be simplified by the new galenical formulation.

the ratio of active compound to carrier material can vary within wide limits. Since the peptides are administered in low dosages, the amount of carrier material in the implants is relatively high (for example 100 : 1 to 10,000 : 1).

#### Example 1:

2.5 g of PMB were moistened with a methanolic solution containing 2.875 mg of buserelin acetate (corresponding to 2.5 mg of buserelin) and mixed thoroughly. The moist material was dried in vacuo, with shaking. The procedure was repeated several times with pure methanol.

15 The dry mixture was pressed to tablets (implants) weighting 50 mg and containing 50 µg of buserelin.

#### Example 2:

+ 4 7 45

2.875 mg of buserelin acetate (corresponding to 2.5 mg of buserelin) were dissolved in 30 ml of methanol, 20 and 2.5 g of PHB were dissolved in 70 ml of chloroform. The two solutions were combined and subjected to spraydrying. A flaky powder was obtained, from which tablets weighing 50 mg and containing 50 µg of buserelin were pressed.

#### Example 3:

The pressed pieces prepared under Example 1 or 2 were micronized. The resulting particles were divided into particle size ranges up to about 200 µm by sieving.

5 The fractions were suspended in physiological saline solution with 1% of carboxymethylcellulose in a concentration of 50 mg/ml for injection.

#### Example 4:

2.5 g of PMB were dissolved in 25 g of chloroform.

10 287.5 mg of buserelin acetate (corresponding to 250 mg of buserelin) were suspended in this solution. The suspension was powred into a Petri dish. The solvent was allowed to evaporate slowly. A film was formed, and divided into flakes 1 cm<sup>2</sup> in size, containing about 5 mg 15 of buserelin.

#### Example 5:

### Biological testing of the formulations on rats

Two implantation materials of PHB and a copolymer of lactic acid and glycolic acid (PLG) of identical 20 weight and size which had been prepared analogously to Example 1 were investigated. The materials were tested on adult rats weighing 400 g, the amount of peptide released each day being determined by pharmacokinetic detection by means of specific radioimmunoassay. In the case of the PKB implant, a release of 0.203 ± 0.038 ng of buserelin per day was found. In contrast, a release of 1.075 ÷ 0.029 ng of buserelin/day was found for the PLG implant. The total duration of the release of the peptide

was calculated from the cumulative rate of release. It is 221 ± 29 days for the PHB implant and 46.5 ± 1.2 days for the PLG implant. The PHB implant material is thus considerably more suitable for long-term release of peptides than the copolymer of lactic acid and glycolic acid 150:50; used for comparison.

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# THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. An implant containing a regulatory peptide or one of its analogs as the active compound and naturally occurring pot; -p(-)-3-hydroxybutyric acid of the formula

in which n represents a number between 500 and 25,000, as the biologically degradable carrier.

- 2. Implant as claimed in claim 1, which contains buserelin(acetate) as the active compound.
- 3. A process for the preparation of an implant as claimed in claim 1, which comprises
- 1. dissolving the active compound in a low-molecular alcohol which has 1 to 4 carbon atoms and is optionally substituted by up to 7 fluorine atoms or in water or in a mixture of these two solvents, mixing the solution with the poly-p-(-)-3-hydroxybuty ic acid, drying the moist material and pressing the product, or
- 2. dissolving the poly-D(-)-3-hydroxybutyric acid in a halogenated aliphatic C<sub>1</sub>-C<sub>4</sub>-hydrocarbon, mixing the solution with a solution of the active compound in a low-molecular alcohol which has 1 to 4 carbon atoms and is optionally substituted by up to 3 fluorine atoms, subjecting the resulting solution to spray-drying and pressing the dried material, or
- 3. dissolving the poly-D(-)-3-hydroxybutyric acid in

a halogenated aliphatic C1-C4-hydrocarbon, suspending the active compound in this solution, pouring the suspension onto a suitable substrate, evaporating off the solvent and, if appropriate, dividing up the resulting film into pieces of suitable size.

- 4. The process as claimed in claim 3, wherein the pressed piece or film is comminuted in a further step and suspended in a solvent suitable for injection purposes.
- 5. The process as claimed in claim 3, wherein the active compound is dissolved methanol.
- 6. The process as claimed in claim 3, wherein the carrier substance is dissolved in chloroform.

DATED THIS 31st day of July, 1984

HUECHST AKTIENGESLLSCHAFT

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(19) AU

(54)	REGULATORY PEPTIDE IN BIODEGRADABLE CARRIER		ACID AS A
(71)	HOECHST AKTIENGESELLS	CHAFT	
(Z1)	31399/84 (Z2) 1.8.	84	(24) 2.8.83
(31)	332,856 (32) 2.8. 3336197 5.10		
(43)	<b>14,9,86</b>		
(51)3		7/02	
1721	NOT GIVEN		
¥74)	120%		
(57)	. Implant include	s tablets, flakes ar	nd injections
Odeim	. •		•

1. An implent containing a regulatory peptide or one of its analogs as the active compound and naturally occurring poly-D(-)-3-hydroxybutyric acid of the formula

in which a represents a number between 500 and 25,000, as the biologically degradable carrier.

#### COMMONWEALTH OF AUSTRALIA

PATENTS ACT 1952-69

# COMPLETE SPECIFICATION

(ORIGINAL)

Class

int. Class

Application Number: Longest

Complete Specification Lodged:

Accepted:

Published:

Priority:

Related Art.

Name of Applicant:

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Complete Specification for the invention entitled:

PHARMACEUTICAL PRODUCTS WITH PROTRACTED RELEASE WHICH CONTAIN REGULATORY PEPTIDES, AND PROCESSES FOR THEIR PREPARTATION

The following statement is a full description of this invention, including the best method of performing it known to :-

The invention relates to a formulation, which can be implanted, of regulatory peptides and of analogs thereof with protracted release, and to processes for the preparation of the implants.

ovitro experiments, the active compound is released slowly from matrix tablets containing 7-hydroxyethyltheophylline, as the active compound, and poly-D(-)-Z-hydroxybutyric acid, as the biologically degradable carrier material (Pharm. Ind. 45, pages 525-527 (1983)).

It has furthermore been reported that the peptides are released slowly from medicaments containing peptides as the active compounds and biodegradable polymers as carrier substances. The carriers are chiefly synthetic polyesters of lactic acid and copolymers of lactic acid and glycolic acid (c.f. for example, European Patent Applications publication numbers 0,052,510 and 0,058,481) and synthetic amino acid polymers (c.f. U.S. Patent 4,351,337). The disadvantage of synthetic polymers is that residues of the polymerization catalyst must be reckoned with. Such residues are undesirable in medicaments, especially in implants.

It has now been found that naturally occurring polyhydroxybutyric acid is suitable as a carrier for 25 peptide-containing implants from which the active compound is released in a protracted manner.

The invention thus relates to implants containing regulatory peptides or analogs thereof as the active compounds and naturally occurring poly-p-(-)-3-hydroxybuty-ric acid (PHB) of the formula

in which a represents a number between 500 and 25,000, as the biologicalty degradable carrier.

In the statements made above and below, "peptides" means regulatory peptides and analogs thereof, as 10 well as physiologically acceptable salts thereof.

The invention furthermore relates to processes for the preparation of implants containing regulatory peptides or analogs thereof as active compounds, which comprise

- 15 1. dissolving the active compound in a low-molecular alcohol which has 1 to 4 carbon atoms and is optionally substituted by up to 3 fluorine atoms or in water or in a mixture of these solvents, mixing the solution with the poly-D-(-)-3-hydroxybutyric acid, drying the moist mate
  - dissolving the poly-D(+)-3-hydroxybutyric acid in a halogenated aliphatic  $C_1$ - $C_4$ -hydrocarbon, mixing the solution with a solution of the active compound in a low-molecular alcohol which has 1 to 4 carbon atoms and is
- 25 optionally substituted by up to 3 fluorine atoms, subjecting the resulting solution to spray-drying and

pressing the dried cottonwool-like material, or

3. dissolving the poly-D(-)-3-hydroxybutyric acid in a halogenated alignatic C<sub>1</sub>-C<sub>4</sub>-hydrocarbon, suspending the active compound in this solution, pouring the suspension onto a sustable substrate; for example into a glass

dish, evaporating off the softent and, if appropriate, dividing up the resulting film into pieces of suitable size.

The resulting pressed pieces or films can be 10 gro. nd and divided into various particle sizes by sieving.

The solid shaped articles can be implanted as such or, after prior comminution, injected in the form of suspensions.

The regulatory peptides (naturally occurring,

15 synthetic and semi-synthetic), which can also be used in
the form of salts, are soluble in water and low-molecular
alcohols which are optionally substituted by fluorine.

Possible alcohols are, in particular, methanol and trifluoroethanol. Particularly suitable solvents for the

20 PHB are fluorinated and chlorinated hydrocarbons, such as
methylene chloride, chloroform and 1,1,2-trichloro-1,2,3trifluoroethane, methylene chloride and chloroform being
especially suitable.

The PHB is synthesized by bacteria, such as, for 25 example, by Alcaligenes eutrophus. It is obtained in the form of small globules in the bacteria and can be greatly increased in concentration by corresponding conditions in the bacteria and easily isolated therefrom (c.f. Pharma.

Ind. 45, pages 525-527). Each unit of PHB consists of optically pure D-(-)-3-hydroxybutyric acid.

relatively slowly and contributes little to the release

of an active compound from an implant. The release is
chiefly controlled by the surface of the implant and the
amount of active compound contained therein. If very
small amounts of a peptide are to be released for a relatively long time, an impant with a small surface area and
low peptide content, for example in the form of pressed
pieces, is advisable. The release from the pressed piece
can be further reduced by coating the implant completely
or partly with a layer of PHS or other biologically
degradable polymers, such as polylactic acid or polylac
15 tic acid/polyglycolic acid copolymers or with polymers
such as ethylcellulose, poly(meth)acrylic acid derivatives or polydimethylsiloxanes.

An essentially uniform release of peptides for up to one year can be achieved with such impants. The im20 plants can easily be removed by operation, if the treatment is to be discontinued.

Whilst the implantation tablets prepared according to method 1 release a relatively constant amount of a regulatory peptide from the start, the implants obtained according to method 2 release a relatively large amount of peptide in the first days and then release constant small amounts. Good adaptation to the desired pattern of release of the active compound is thus possible with the

implants according to the invention.

These slow rates of release are surprising when compared with the rates of release of about 40 days, which in contrast are rapid, obtained with the copolymers of lastic acid and glycolic acid (c.f. European Patent Application publication number 0,658,481).

throughout which the entire dose is distributed are suitable as implants for shorter release times. As a result 10 of the substantially larger surface area which a large number of medicinal carriers have in comparison with a single shaped piece, the release is more rapid. Small particles which can be prepared by comminution of tablets and films are preferred. They can be injected, 15 after suspension in a suitable medium. The particle size should not exceed a particular value here and is advantageously in the range from 0.1 to 200 µm.

Physiological saline solution in which, for example, 1% of hydroxypropylmathylcellulose (Methocel R 20 E5), carboxymethylcellulose (Blanose R 7LF) or polyethylene glycol sorbitan monostearate (Tween R 20) is dissolved can be used for suspension and injection of the particles.

Regulatory peptides are endogenous peptides which 25 have a physiological action, they are also called peptide hormones, which, depending on the site of synthesis or release, are classified into, for example, peptide hormones of the hypothalamus, of the pituitary gland, of the

gastrointestinal tract or of the thyroid gland. This classification is inappropriate today, since it is known that the so-called peptide hormones are not produced only at one site in the body and, in addition to their endonce of action, can also set in a paracrine or neurocrine manner.

indications is also inapprepriate, since they can develop the most diverse therapeutic activities, depending on the 10 site of action and the dose,

Examples of representative regulatory peptides
which the implants according to the invention can contain
are oxytocin, vasopressin, thyroliberin the anorexigenic
peptide, genadotiberin, calcitonin, parathormone the

15 epidermal growth factor, secretin the vasoactive intestinal peptide, somatoliberin the gastrin-inhibiting or
glucose-dependent insulinotropic peptide, glucagon the
pancreatic spasmolytic peptide, somatostatin, bombesin
the gastrin-releasing peptide, motilin, neutrotensin,
20 substance P, sauvagin, corticoliberin, urotensin I and
II, angiotensin I and II, bradykinin, corticotropin,
encephalins, dynorphin, dermophin, casomorhins, gastrin,
cholecystokin, cerulein, thymus factors, interferons,

insulin, growth hormone and prolaction.

The highly active analogs of genadoliberin, such as, for example, ED-Ser(Bu<sup>t</sup>) 6]gonadoliberin-(1-9)nona-peptide-ethylamide (buserelin, Drugs of the Future 4, 1979, pages 175-77, 8, 1983, page 254), ED-Trp6]

gonadoliberin (Drugs of the Future 3, 1978, pages 645-646), [D-Trp<sup>6</sup>]gonadoliberin(1-9)-nonapeptide-ethy(amide (Drugs of the Future 1, 3982, pages 637-642), [D-Leu<sup>6</sup>] gonadoliberin(1-9)-nonapeptide-ethy(amide (Drugs of the

Future 7. 1982, pages 882-886), FEL-Ser(But, 5, Azasty 19, gomedo, Crberth (Drugs of the Future 5- 1980, pages 191-792, 8, 1985, pages 54-365), ED-Thop, N-Meteu/J conside Noerfor (1-99)+monate tilez-ethy tamede communs of Ather Future 8, 1985, pages 344-350). ED-Thop and 6 The Future 8, 1985,

40 ester<sup>6</sup>I ganadoliberia-(i-9) nonapeptade-ethytamide (German OffenLegengsschrict 3,620,746), DD-Lys(Boc)<sup>6</sup>I ganadoliberia(1-9)-nonapeptide-ethytamide (German Patent 2,438,350),
[D-3-(2,4,6-trinsthytphehyt)-) La<sup>6</sup>I ganadoliberia (d. Nec. Chem. 25,
[D-3-(2-naphthyt)-Ala<sup>6</sup>I ganadoliberia (d. Nec. Chem. 25,
15 1982, pages 795-801), are of particular importance.

plasma levels of lutropin and follitropin and hence those of the general steroids testosterone and oestradiol.

These derivatives can therefore be used for hormone—

20 dependent tumors, such as, for example, carcinoma of the prostate or of the breast, and also for endometriosis and pubertas preacox in children. Continuous uniform release of the active compound is particularly important for this therapy. With the formulation according to the invention,

25 the necessary amount of the active compound, which would otherwise have to be administered parenterally or intranasally 2-3 times daily, can be released for weeks or months with a single administration. Use on older persons

**●** ● ● ● and children is thus particularly safe from administration errors (compliance).

Another important use of the formulation according to the invention is the protracted release of somatostatin 5 and somatostatin analogs, which can be used in all cases where sometostatin infusions exhibit an advantageous effect; for example for hemorrhages of the gastrointestinal treet, for gestric ulsers, for the treatment of tumors which produce hormones which can be inhibited by 10 sometostatin, such as, for example, for Zollinger-Ellison syndrone or Werner-Morrison syndrone, or for tunors which produce insulin or glucagon, for hormone-dependent tumors, if the corresponding hormones can be inhibited by somatostatin, for certain types of leukemia, for metabolism dis-15 orders with increased hormone levels which can be inhibited by sometostatio, such as, for example, rheumatoid erthritis, where the plasma insulin and growth hormone are too high, for acromegaly or psoriasis, for Diabetes mellitus (inhibition of glucagon), for chondrosarcoma and 20 for states of shock.

Highly active analogs of somatostatin are compounds in which, for example, Trp<sup>8</sup> is replaced by D-Trp or 5-F-D-Trp, or shortened cyclic compounds, such as, for example,

Pro-Phc-D-Trp-Lys-Thr-Phe-

(Nature 292, 1981, page 55) or

25

H-D-Phe-Cys-Phe-D-Trp-Lys-Thr-Cys-Thr-ol

(Life Sci. 31, 1982, pages 1,133-1,148).

Therapy of upper gastrointestinal hemorr' iges with secretin infusions can also be simplified by the new galenical formulation.

The ratio of active compound to carrier material 5 can vary within wide limits. Since the peptides are administered in low dosages, the amount of carrier material in the implants is relatively high (for example 100 : 1 to 10,000 : 1).

#### Example 1:

- 2.5 g of PMB were moistened with a methanolic solution containing 2.875 mg of buserelin acetate (corresponding to 2.5 mg of buserelin) and mixed thoroughly. The moist material was dried in vacuo, with shaking. The procedure was repeated several times with pure methanol.
- 15 The dry mixture was pressed to tablets (implants) weighing 50 mg and containing 50 µg of buserelin.

#### Example 2:

2.875 mg of buserelin acetate (corresponding to 2.5 mg of buserelin) were dissolved in 30 ml of methanol, 20 and 2.5 g of PHB were dissolved in 70 ml of chloroform. The two solutions were combined and subjected to spraydrying. A flaky powder was obtained, from which tablets weighing 50 mg and containing 50 µg of buserelin were pressed.

#### Example 3:

The pressed pieces prepared under Example 1 or 2 were micronized. The resulting particles were divided into particle size ranges up to about 200 µm by sieving.

5 The fractions were suspended in physiological saline solution with 1% of carboxymethylcellulose in a concentration of 50 mg/ml for injection.

#### Example 4:

2.8 g of PMB were dissolved in 25 g of chloroform.

10 287.5 mg of buserelin acetate (corresponding to 250 mg of buserelin) were suspended in this solution. The suspension was powred into a Petri dish. The solvent was allowed to evaporate slowly. A film was formed, and divided into flakes 1 cm<sup>2</sup> in size, containing about 5 mg 15 of buserelin.

#### Example 5:

## Biological testing of the formulations on rats

Two implantation materials of PHB and a copolymer of lactic acid and glycolic acid (PLG) of identical 20 weight and size which had been prepared analogously to Example 1 were investigated. The materials were tested on adult rats weighing 400 g, the amount of peptide released each day being determined by pharmacokinetic detection by means of specific radioimmunoassay. In the 25 case of the PHB implant, a release of 0.203 ± 0.038 ng of buserelin per day was found. In contrast, a release of 1.075 ÷ 0.029 ng of buserelin/day was found for the PLG implant. The total duration of the release of the peptide

was calculated from the cumulative rate of release. It is 221 ± 29 days for the PHB implant and 46.5 ± 1.2 days for the PLG implant. The PHB implant material is thus considerably more suitable for long-term release of pep-5 tides than the copolymer of lactic acid and glycolic acid. 50.50% used for comparison.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLUNS: RAXENEXEENES

1. An implant containing a regulatory peptide or one of its analogs as the active compound and naturally occurring poty-p(-)-3-hydroxybutyric acid of the formula

in which n represents a number between 500 and 25,000, as the biologically degradable carrier.

- 2. Implant as claimed in claim 1, which contains buserelin(acetate) as the active compound.
- 3. A process for the preparation of an implant as claimed in claim 1, which comprises
- 1. dissolving the active compound in a low-molecular alcehol which has 1 to 4 carbon atoms and is optionally substituted by up to 7 fluorine atoms or in water or in a mixture of these two solvents, mixing the solution with the poly-p-(-)-3-hydroxybuty ic acid, drying the moist material and pressing the product, or
- 2. dissolving the poly-D(-)-3-hydroxybutyric acid in a halogenated aliphatic C<sub>1</sub>-C<sub>4</sub>-hydrocarbon, mixing the solution with a solution of the active compound in a low-molecular alcohol which has 1 to 4 carbon atoms and is optionally substituted by up to 3 fluorine atoms, subjecting the resulting solution to spray-drying and pressing the dried material, or
- 3. dissolving the poly-D(-)-3-hydroxybutyric acid in

a halogenated aliphatic C1-C4-hydrocarbon, suspending the active compound in this solution, pouring the suspension onto a suitable substrate, evaporating off the solvent and, if appropriate, dividing up the resulting film into pieces of suitable size.

- 4. The process as claimed in claim 3, wherein the pressed piece or film is comminuted in a further step and suspended in a solvent suitable for injection purposes.
- 5. The process as claimed in claim 3, wherein the active compound is dissolved methanol.
- 6. The process as claimed in claim 3, wherein the carrier substance is dissolved in chloroform.

DATED THIS 31st day of July, 1984

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